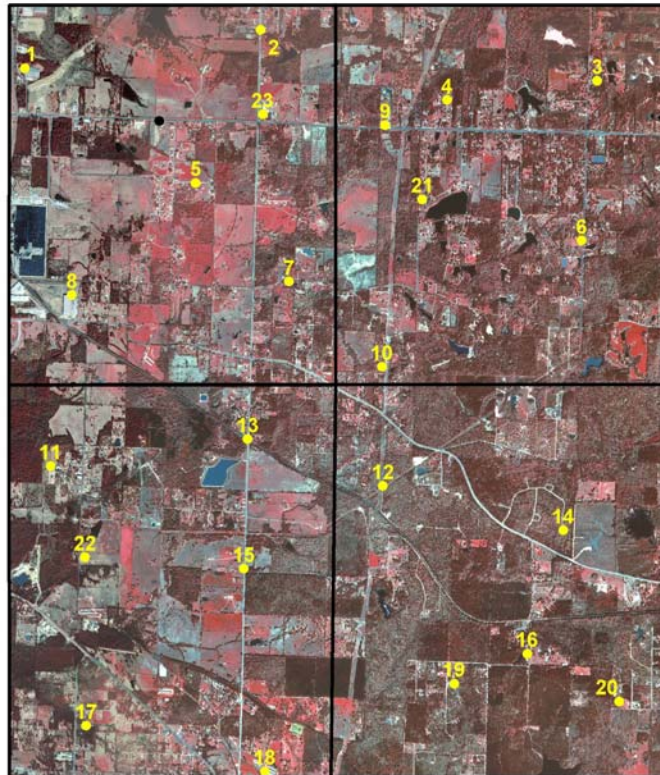# Arkansas
Mandeville SW Digital
Ortho Quarter Quadrangle

National Standard for Spatial Data Accuracy Report

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http://www.gis.state.ar.us/SGIC/ADOP/assess.htm

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Background

The Arkansas State Land Information Board (ASLIB) contracted Pixxures to produce second generation Digital Ortho Quarter Quadrangles (DOQQ's) for the State of Arkansas. The project began January 15, 2001 and was termed ADOP (Arkansas Digital Ortho Program). Through ADOP the state will receive 1-meter resolution, color contrast / balanced, seamless edge matched, feather adapted Geo-Tiff images, Mr. Sids 5:1 compressed images and standard United States Geological Survey (USGS) DOQQ's.

The project is coordinated through the Arkansas State Land Information Coordinator's Office (ASLIC) and funded by contributors throughout the state including: Arkansas Game and Fish Commission, Economic Development of Arkansas Fund, Benton County, Crawford County, Sebastian County, The Ross Foundation, The Timber Company, International Paper, Weyerhaeuser, U.S. Forest, Little Rock District- U.S. Army Corps of Engineers, Service and U.S. Geological Survey. The history and status of the ADOP project can be tracked via the web at: http://www.gis.state.ar.us/.

Abstract

The Federal Geographic Data Committee (FGDC) established the National Standard for Spatial Data Accuracy (NSSDA) in 1998. The NSSDA provides a "statistical and testing" methodology for reporting the accuracy of vector and raster graphics. These methodologies enable one to compare the coordinates of an independent data set to the coordinates of the test data set to determine the horizontal or vertical accuracy of the test data set. This document will examine the horizontal accuracy of a second-generation digital orthophoto quarter quadrangle (DOQQ) produced by Pixxures. The independent data set was created utilizing Global Positioning System technologies. The test data set was created by heads-up digitizing points on the second-generation DOQQ. Reporting the accuracy of spatial data following a common methodology allows end users of the spatial data to determine its usefulness.

Keywords

 accuracy assessment, digital orthophoto quarter quadrangle (DOQQ), independent data set, National Standard for Spatial Data Accuracy, test data set

Definitions

Independent points (data set)- fixed positions collected utilizing GPS methodologies, creating a data set of a higher degree of accuracy than the one being tested.

Test points- positions that could be visually interpreted on the DOQQ and in the field. These positions were compiled manually utilizing heads-up digitizing methodologies.

Purpose

1. Determine the accuracy of the Mandeville SW DOQQ
2. Demonstrate the proper use of NSSDA reporting methodologies
3. Demonstrate not all DOQQ's are of the same accuracy
4. Determine the accuracy of a Pixxures DOQQ

Accuracy Assessment

An accuracy assessment (AA) of the second generation Mandeville Southwest (Geo-Tiff) DOQQ was conducted utilizing methodologies presented in the NSSDA (appendix I). The AA will provide those using the Mandeville SW second generation DOQQ with its known horizontal accuracy. This will insure that spatial data created utilizing the second generation DOQQ can be performed with known horizontal accuracies. This document will present the methodologies used while performing the AA on the second-generation Mandeville SW DOQQ. Utilizing the methodologies detailed in this document will enable one to acquire results similar to those found in the assessment performed on July 17, 2001.

Results

The Mandeville SW second generation DOQQ tested 5-meters (16-feet) horizontal accuracy at 95% confidence level.

Location

The Mandeville SW quarter quad (shown in red) is located in Miller County (blue). The Mandeville SW quarter quadrangle is approximately one-hundred and thirty-seven miles southwest of Little Rock on interstate 30.

Figure 1

The area encompassed by the Mandeville SW DOQQ is characterized as both rural and urban. A number of photo interpretable land cover is present, including: hardwood, softwood, agriculture, urban and hydrologic features.

The Selection of Independent Points

The NSSDA provides guidelines for selecting independent points prior to performing fieldwork.   During the pilot (Lewisville NW, May 15, 2001), it was observed that the NSSDA guidelines (appendix II) were difficult to follow due to accessibility in rural areas, and visual interpretation of the DOQQ. To this end a considerable amount of mission planning time was spent, prior to performing the fieldwork. Specific attention was given to the ability to interpret independent points and the accessibility to the predetermined sites.

Figure 2 illustrates the distribution of the independent points selected. A detailed description of each point is provided in appendix III.

Figure 2
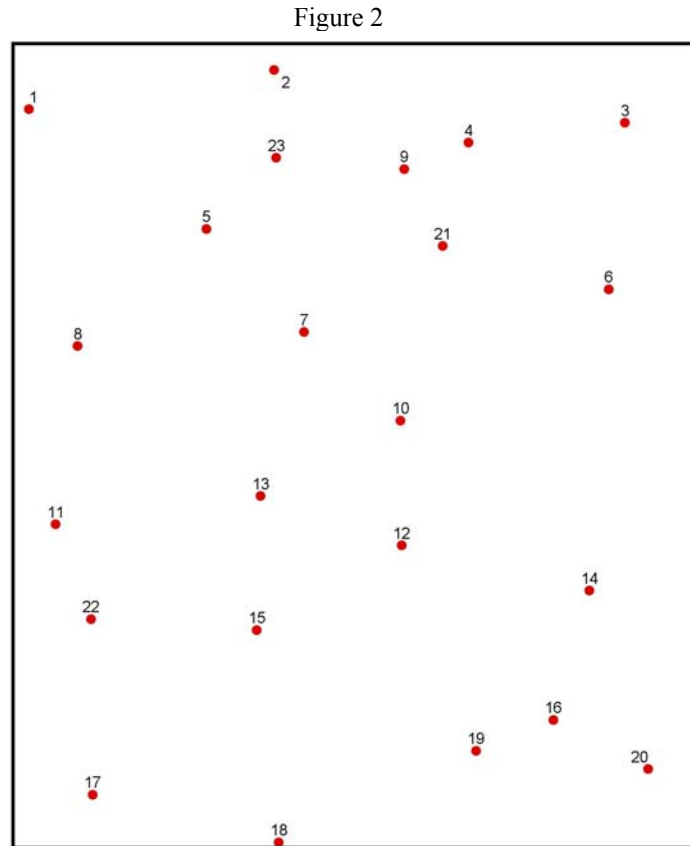
Developing Independent and Test Datasets
Utilizing ArcView 3.1 software, and the second generation Mandeville SW DOQQ (Geo-Tiff), independent points were selected. Independent points that were believed to represent a strong contrast change were examined and a point was placed in the center of converging pixel change at a scale of 1:0 (Figure 3).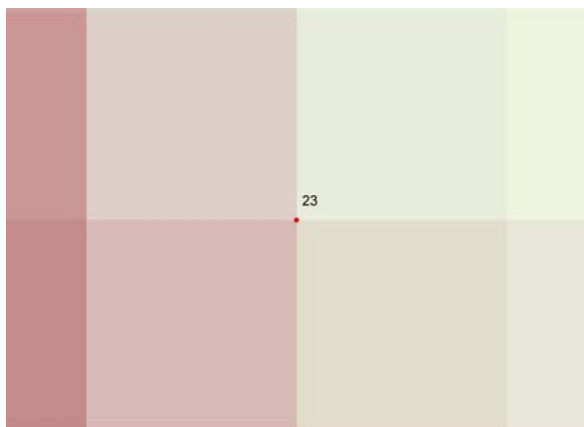 The points manually placed on the DOQQ served as the test data set. The coordinates for the independent points were acquired utilizing GPS methodologies. (Refer to appendix IV for metadata pertaining to the GPS methodologies employed.)

Figure 3

Collecting the coordinates for independent points in the field
A number of "pre-selected independent points" were discarded during fieldwork. These points were deemed un-interpretable in the field due to vegetation change, human impact, or accessibility. To make up the difference for the independent points discarded; independent points were added while in the field. Once all of the independent point coordinates were acquired the data was transferred from a Trimble ProXR to the Trimble Pathfinder Office Software. The independent points were then exported from the Trimble Pathfinder Software to an ArcView shapefile, and viewed in ArcView 3.1. This was done to insure an adequate number of independent points had been collected and properly distributed to perform the statistical analysis specified by the NSSDA, prior to returning to the office. (Refer to appendix V for a complete listing of resources utilized.)

Determining the Difference
In the office test points were adjusted to more precise pixel locations based on knowledge of the area obtained during fieldwork. All test point ID numbers were compared to the filename of the independent data set to insure the two data sets had been properly attributed. Coordinates for the test data set were acquired utilizing the ArcView script Add XY[1]. The coordinates obtained for the independent data set were real time differentially corrected (refer to appendix IV), and exported from Pathfinder Office into an ArcView shapefile. Using the functionality of the Pathfinder software a number of attributes were included with the shapefile. (Refer to appendix VI.)

The coordinates from the test and independent datasets were copied into a NSSDA worksheet[2]. The following information resulted, utilizing the horizontal accuracy work sheet (Table 1).

Table 1

Item	Description
Point Description	unique id number represented in each of the data sets
X (independent)	x coordinate of point from independent data set
X (test)	x coordinate of point from test data set
Difference in X	x (independent) – x (test)
(Difference in X)^2	squared difference in x = (x (independent) – x (test))^2
Y (independent)	y coordinate of point from independent data set
Y (test)	y coordinate of point from test data set
Difference in Y	y (independent) – y (test)
(Difference in Y)^2	squared difference in y = (y (independent) – y (test))^2
(Difference in X)^2 + (Difference in Y)^2	squared difference in x plus squared difference in y equals (error radius)^2
Sum	sum of (Difference in X)^2 + (Difference in Y)^2
Average	sum divided by the number of points
Root Mean Square Error	RMSE (radial) = average $^{1/2}$
National Standard for Spatial Data Accuracy	NSSDA statistic = 1.7308* RMSE

It is important to understand the results observed from the NSSDA test are not a function of good or bad spatial data. The NSSDA is only a statistic to represent the spatial

accuracy of the test data set to that of the independent data set. The NSSDA does not set a standard for what is to be considered accurate data. The end user of the spatial data should determine if the accuracy is acceptable for their project.

Analysis
Utilizing the NSSDA worksheet, the Mandeville SW second generation DOQQ tested 5-meters (16-feet) horizontal accuracy at 95% confidence level (appendix VII). Figure 4 shows the distribution of points across the DOQQ and along the diagonal.

Figure 4
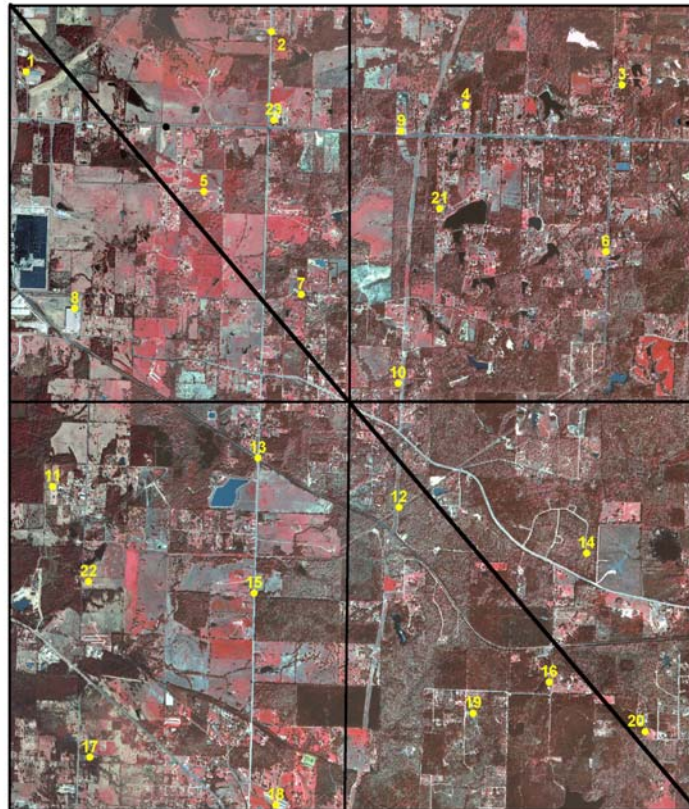
USGS Standards for Digital Orthophotos, part 2.6 of the specifications states "… DOQ's must meet National Map Accuracy Standards (NMAS) at 1:24,000 and 1:12,000 scale respectively. The NMAS specify that 90% of the well-defined points tested must fall within 40 feet at 1:24,000 and 33.3 feet at 1:12,000 scale"[3].
The Mandeville SW DOQQ produced by Pixxures falls within the USGS DOQ specifications.

First and Second Generation DOQQ Comparison

The Mandeville SW first generation DOQQ was used as an overlay. Noticeable displacements were observed between the first and second generation DOQQ's. Figures 5 and 6 illustrate the displacement observed. Figure 5 represents the second generation DOQQ with a 'reference line' (purple) placed along the western edge of the building. Figure 6 represents the first generation DOQQ with the same reference line used in figure 5.

Figure 5 Second Generation DOQQ   Figure 6 First Generation DOQQ

The displacement observed in these two figures represents approximately 9m (30 feet). Independent point number ID 1 (yellow), acquired following the GPS methodologies in appendix II) was overlaid in Figures 7 and 8.

Figure 7 Second Generation DOQQ   Figure 8 First Generation DOQQ

Table 2

DOQQ	X (meters)	Y(meters)	X (feet)	Y(feet)
First Generation	-7	+5	-22	+17
Second Generation	-5	-2	-17	-8

Similar results were observed at a number of other independent points. The first and second generation DOQQ's both fall well within the National Map Accuracy Standards. Due to the large amount of land use change, sufficient test points on the first generation DOQQ could not be acquired at the same location, as the independent points were previously taken. This prevented a NSSDA test being performed on the first generation DOQQ.

Conclusion

Accuracy assessments performed following the NSSDA provide the end user of the geospatial data with known accuracies that follow a common methodology. The horizontal accuracy of the Mandeville SW DOQQ was found to be 5-meters (16-feet) with a 95% confidence level. ***This does not imply that all second generation DOQQ's have the same horizontal accuracy.*** The control points selected and quality of elevation model (data) for the area are major contributors to the accuracy of all DOQQ's. NSSDA tests should be performed on each individual DOQQ when the spatial project requires known accuracies.

Appendix I- Selected Portion of the NSSDA (GeoSpatial Positioning Accuracy Standards Part 3)
        *The complete document can be downloaded http://www.fgdc.gov/standards/status/sub1_3.html
Federal Geographic Data Committee FGDC-STD-007.3-1998
Geospatial Positioning Accuracy Standards
Part 3: National Standard for Spatial Data Accuracy
3.2   Testing Methodology And Reporting Requirements

3.2.1   Spatial Accuracy
        The NSSDA uses root-mean-square error (RMSE) to estimate positional accuracy. RMSE is the
        square root of the average of the set of squared differences between dataset coordinate values and
        coordinate values from an independent source of higher accuracy for identical points . [1]
        Accuracy is reported in ground distances at the 95% confidence level. Accuracy reported at the
        95%confidence level means that 95% of the positions in the dataset will have an error with respect
        to true ground position that is equal to or smaller than the reported accuracy value. The reported
        accuracy value reflects all uncertainties, including those introduced by geodetic control
        coordinates, compilation, and final computation of ground coordinate values in the product.

3.2.2   Accuracy Test Guidelines
        According to the Spatial Data Transfer Standard (SDTS) (ANSI-NCITS, 1998), accuracy testing
        by an independent source of higher accuracy is the preferred test for positional accuracy.
        Consequently, the NSSDA presents guidelines for accuracy testing by an independent source of
        higher accuracy. The independent source of higher accuracy shall the highest accuracy feasible
        and practicable to evaluate the accuracy of the dataset.[2]

        The data producer shall determine the geographic extent of testing. Horizontal accuracy shall be
        tested by comparing the planimetric coordinates of well-defined points in the dataset with [3]
        coordinates of the same points from an independent source of higher accuracy. Vertical accuracy
        shall be tested by comparing the elevations in the dataset with elevations of the same points as
        determined from an independent source of higher accuracy.

        Errors in recording or processing data, such as reversing signs or inconsistencies between the
        dataset and independent source of higher accuracy in coordinate reference system definition, must
        be corrected before computing the accuracy value.

        A minimum of 20 check points shall be tested, distributed to reflect the geographic area of interest
        and the distribution of error in the dataset. When 20 points are tested, the 95% confidence level [4]
        allows one point to fail the threshold given in product specifications.

        If fewer than twenty points can be identified for testing, use an alternative means to evaluate the
        accuracy of the dataset. SDTS (ANSI-NCITS, 1998) identifies these alternative methods for
        determining positional accuracy:
        * Deductive Estimate
        * Internal Evidence
        * Comparison to Source

3.2.3   Accuracy Reporting
        Spatial data may be compiled to comply with one accuracy value for the vertical component and
        another for the horizontal component. If a dataset does not contain elevation data, label for
        horizontal accuracy only. Conversely, when a dataset, e.g. a gridded digital elevation dataset or
        elevation contour dataset, does not contain well-defined points, label for vertical accuracy only.

        A dataset may contain themes or geographic areas that have different accuracies. Below are
        guidelines for reporting accuracy of a composite dataset:
        * If data of varying accuracies can be identified separately in a dataset, compute and report
        separate accuracy values.

* If data of varying accuracies are composited and cannot be separately identified AND the dataset is tested, report the accuracy value for the composited data.
* If a composited dataset is not tested, report the accuracy value for the least accurate dataset component.

Positional accuracy values shall be reported in ground distances. Metric units shall be used when the dataset coordinates are in meters. Feet shall be used when the dataset coordinates are in feet. The number of significant places for the accuracy value shall be equal to the number of significant places for the dataset point coordinates.

Accuracy reporting in ground distances allows users to directly compare datasets of differing scales or resolutions. A simple statement of conformance (or omission, when a map or dataset is non-conforming) is not adequate in itself. Measures based on map characteristics, such as publication scale or contour interval, are not longer adequate when data can be readily manipulated and output to any scale or to different data formats.

Report accuracy at the 95% confidence level for data *tested* for both horizontal and vertical accuracy as:

Tested ____ (meters, feet) horizontal accuracy at 95% confidence level
____ (meters, feet) vertical accuracy at 95% confidence level

Appendix II- (GeoSpatial Positioning Accuracy Standards Part 3- Appendix 3-C)
      *The complete document can be downloaded http://www.fgdc.gov/standards/status/sub1_3.html

Part 3: National Standard for Spatial Data Accuracy
Appendix 3-C (informative): Testing guidelines
Page 3-17

1.   Well-Defined Points

A well-defined point represents a feature for which the horizontal position is known to a high
degree of accuracy and position with respect to the geodetic datum. For the purpose of accuracy
testing, well-defined points must be easily visible or recoverable on the ground, on the
independent source of higher accuracy, and on the product itself. Graphic contour data and
digital hypsographic data may not contain well-defined points.

The selected points will differ depending on the type of dataset and output scale of the dataset.
For graphic maps and vector data, suitable well-defined points represent right-angle intersections
of roads, railroads, or other linear mapped features, such as canals, ditches, trails, fence lines,
and pipelines. For orthoimagery, suitable well-defined points may represent features such as
small isolated shrubs or bushes, in addition to right-angle intersections of linear features. For
map products at scales of 1:5,000 or larger, such as engineering plats or property maps, suitable
well-defined points may represent additional features such as utility access covers and
intersections of sidewalks, curbs, or gutters.

2. Data acquisition for the independent source of higher accuracy
The independent source of higher accuracy shall be acquired separately from data used in the
aerotriangulation solution or other production procedures. The independent source of higher
accuracy shall be of the highest accuracy feasible and practicable to evaluate the accuracy of the
dataset.

Although guidelines given here are for geodetic ground surveys, the geodetic survey is only one
of many possible ways to acquire data for the independent source of higher accuracy. Geodetic
control surveys are designed and executed using field specifications for geodetic control surveys
(Federal Geodetic Control Committee, 1984). Accuracy of geodetic control surveys is evaluated
using Part 2, Standards for Geodetic Networks (Federal Geographic Data Committee, 1998). To
evaluate if the accuracy of geodetic survey is sufficiently greater than the positional accuracy
value given in the product specification, compare the FGCS **network accuracy** reported for the
geodetic survey with the accuracy value given by the product specification for the dataset.
Other possible sources for higher accuracy information are Global Positioning System (GPS)
ground surveys, photogrammetric methods, and data bases of high accuracy point coordinates.

3. Check Point Location
Due to the diversity of user requirements for digital geospatial data and maps, it is not realistic to
include statements in this standard that specify the spatial distribution of check points. Data
and/or map producers must determine check point locations. This section provides guidelines for
distributing the check point locations.

Check points may be distributed more densely in the vicinity of important features and more
sparsely in areas that are of little or no interest. When data exist for only a portion of the dataset,
confine test points to that area. When the distribution of error is likely to be nonrandom, it may be desirable
to locate check points to correspond to the error distribution.

For a dataset covering a rectangular area that is believed to have uniform positional accuracy,
check points may be distributed so that points are spaced at intervals of at least 10 percent of the
diagonal distance across the dataset *and* at least 20 percent of the points are located in each
quadrant of the dataset.

Appendix III- Detailed description of the independent points collected.

ID	Description
1	NW corner of building located on Jim Walter Dr.
2	S corner where driveway meets pavement on Rondo Rd.
3	NE corner of garage of home located on Mosley Rd.
4	SW corner of where driveway meets pavement on Palamino Rd., house #1108
5	N side of where driveway meets asphalt at home #316 on Meadows Rd.
6	SW corner of driveway, where pavement meets asphalt on Mosley Rd.
7	NW corner of mobile home on Tennessee Rd.
8	NE corner of building on Tennessee Rd.
9	NW corner of gas pump awning at gas station on 9th St.
10	SE corner of home on County Road 297
11	NW corner of mobile home located on Will Greer Rd.
12	NE corner of intersection of power lines
13	NW corner of intersection of asphalt and rail road tracks on County Road 237
14	Northern point of island of grass and saplings in subdivision development off of State Highway 196
15	N corner of driveway meeting Beasley Hill Rd.
16	NW corner of building located on County Rd. 295
17	SW corner of corrugated metal building located on Blackman Ferry Rd.
18	SW corner of chicken house located on County Road 306
19	NE corner of home
20	NW corner of corrugated tin shack off of County Road 290
21	SE corner of red brick home on County Road 281
22	SW corner of shed beside home on County Road 46
23	SW corner of Baptist Orphanage at intersection of 9th St. and Rondo Rd.

Appendix IV- GPS Metadata

GPS Metadata

Type of receiver	Trimble ProXR
Accuracy of receiver as stated by manufacturer	sub meter
Approximate distance from the base station used for differential correction	50.3 miles
Base station used for differential correction	CORS, De Queen, Arkansas
	Latitude 34° 06' 38.36664" N
	Longitude -94° 17' 23.63158" W
	Elevation 169.711 m HAE
	http://www.ngs.noaa.gov/cors/arkansas_dqua.html
Coordinate system	Geographic (lat/long)
Datum	WGS 84
Date of collection	05/23/01
Differential correction applied	Real Time Differential Correction was used
Elevation Model	Height above Ellipsoid
Minimum number of positions for point feature	60
PDOP Mask	Maximum of 6
SNR Mask	Minimum of 6
Units of Measure	meters
Vertical accuracy as stated by manufacturer	meter

Appendix V- Resources utilized while performing the NSSDA
- Trimble Pro XR
- Dell Latitude CPI Laptop
- Hand held compass
- Arc View 3.1
- 2nd generation color infrared DOQQ of Mandeville SW quarter quadrangle, and surrounding DOQQ's
- Pathfinder Office software
- Tiger line files (used for orientation purposes)
- Hardcopy of the Mandeville SW quarter quadrangle with pre-selected points overlaid
- Approximately 30 man-hours.

Appendix VI- Attributes exported with the Independent data set

Shape	Date	Time
File_name	Picture name	Max_pdop
Corrected_type	Reciever Type	GPS-date
GPS_time	Feat_name	Datafile
Unfiltered_positions	Filtered_positions	Updated_station
Standard deveation	GPS_height	Horizontial_Precission
Vertical_Precission	Latitude	Longitude
Point ID	Data_dictionary	GPS_week GPS_second

Appendix VII- Horizontal Accuracy Worksheet Results from the NSSDA Test Performed on the Second Generation DOQQ

A Point number	B Point description	C x (independent)	D x (test)	E diff in x	F (diff in x)^2	G y (independent)	H y (test)	I diff in y	J (diff in y)^2	K (diff in x)^2 + (diff in y)^2
1		406816.48029	406819.00000	-2.51971	6.34893848	3699929.21004	3699935.00000	-5.78996	33.5236368	39.87257529
2		409134.07761	409133.99996	0.07765	0.00602952	3700307.30632	3700307.00005	0.30627	0.09380131	0.099830835
3		412444.13971	412446.00043	-1.86072	3.46227892	3699804.93721	3699805.00015	-0.06294	0.00396144	3.466240362
4		410967.23490	410967.99995	-0.76505	0.5853015	3699615.65536	3699617.99995	-2.34459	5.49710227	6.08240377
5		408494.59766	408492.00001	2.59765	6.74778552	3698799.19740	3698801.99999	-2.80259	7.85451071	14.60229623
6		412289.79127	412291.00036	-1.20909	1.46189863	3698231.37795	3698232.00004	-0.62209	0.38699597	1.848894596
7		409415.50076	409414.99995	0.50081	0.25081066	3697827.55243	3697827.00017	0.55226	0.30499111	0.555801764
8		407276.72565	407275.99994	0.72571	0.526655	3697694.99618	3697695.99999	-1.00381	1.00763452	1.53428952
9		410358.35432	410359.99998	-1.64566	2.70819684	3699368.10544	3699368.99996	-0.89452	0.80016603	3.508362866
10		410327.85219	410326.99999	0.8522	0.72624484	3696988.49778	3696989.99988	-1.5021	2.25630441	2.982549251
11		407067.83370	407070.00001	-2.16631	4.69289902	3696016.19796	3696015.00015	1.19781	1.4347488	6.127647812
12		410337.14814	410336.00009	1.14805	1.3180188	3695820.43901	3695814.99993	5.43908	29.5835912	30.90161005
13		409006.99708	409005.00011	1.99697	3.98788918	3696282.73187	3696282.00018	0.73169	0.53537026	4.523259437
14		412109.84829	412109.50212	0.34617	0.11983367	3695385.24163	3695387.49684	-2.25521	5.08597214	5.205805813
15		408970.65649	408969.00025	1.65624	2.74313094	3695006.84845	3695014.00012	-7.15167	51.1463838	53.88951473
16		411756.62890	411758.99986	-2.37096	5.62145132	3694169.28048	3694166.00000	3.28048	10.761549	16.38300035
17		407420.47093	407418.99999	1.47094	2.16366448	3693459.75908	3693459.00008	0.759	0.576081	2.739745484
18		409175.89014	409175.99991	-0.10977	0.01204945	3693008.67955	3693008.00021	0.67934	0.46150284	0.473552288
19		411037.56787	411039.00003	-1.43216	2.05108227	3693874.98255	3693874.00015	0.9824	0.96510976	3.016192025
20		412660.95803	412662.00006	-1.04203	1.08582652	3693700.16615	3693699.99979	0.16636	0.02767565	1.113502171
21		410723.36173	410723.99986	-0.63813	0.4072099	3698637.34995	3698639.99991	-2.64996	7.022288	7.429497896
22		407407.17568	407403.00009	4.17559	17.4355518	3695117.94846	3695117.99963	-0.05117	0.00261837	17.43817022
23		409155.54883	409153.00002	2.54881	6.49643242	3699474.45163	3699474.00002	0.45161	0.20395159	6.700384008

sum	198.9270746
average	9.946353732
RMSE	3.153784034
NSSDA	5.458569406

Accuracy Assessment
Mandeville SW Second Generation DOQQ